LUBRICATION

A Technical Publication Devoted to the Selection and Use of Lubricants

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The Time Element in Marine Reciprocating Steam Engine Operation

THE operating efficiency of virtually any type of industrial machine today is measured in dollars and cents as indicated by its productive ability. In turn, transportation machinery has come to be viewed from a somewhat similar angle. In other words, unless we can produce at low cost and distribute to the ultimate consumer in the least possible time, the benefits of our mass production civilization may be largely discounted due to interest and storage expense.

In the exporting and importing field where marine transportation is a necessity, and in the handling of freight and passenger service over inland or coastwise waterways, the economic advantages of such methods of transportation can only be assured provided ship movements can be maintained with the least possible time out for repairs.

Marine operations are distinctly different from land transportation. In the latter failure of a locomotive or truck is disturbing but not usually destructive of schedules, for replacements are available on but short notice, and the load goes on. Failure of a bearing in a marine engine, however, means but one thing—repairs before operation and ship movements can be resumed. This is why lubrication is so very important. In reality, it is the secret of efficient marine steam transportation.

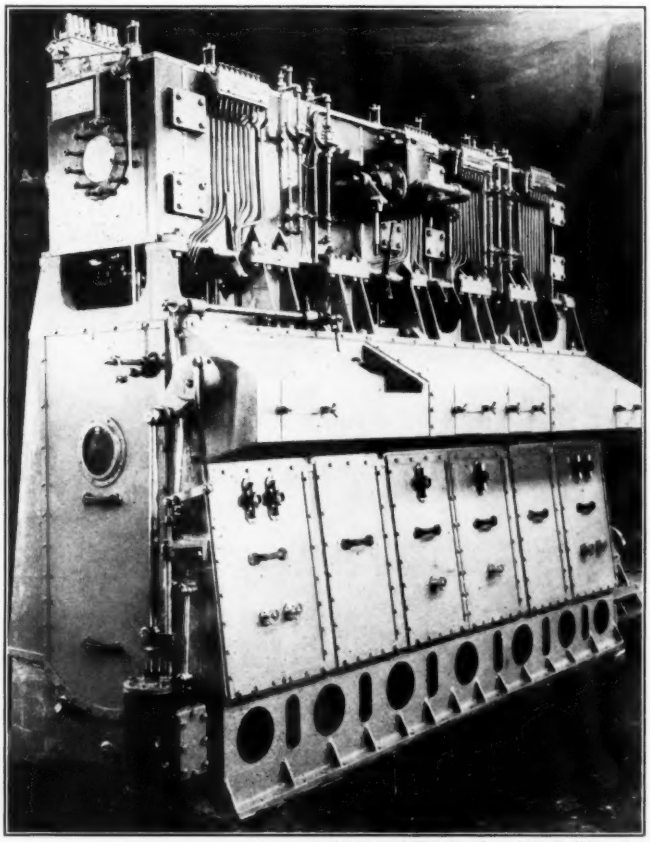
The reciprocating steam engine is probably the most intriguing means employed for ship propulsion. It has become such because of its historical background and the way in which it has been perfected to meet the competition of the turbine and Diesel. Furthermore, it is massive, imposing and radiating of power. Perhaps this is why the throb of the engines is so comforting to the average landsman, who is sympathetic with simplicity in design and impressed with that pleasing oily odor so familiar in the average engine room. One has but to look down from the topside on the cylinder heads of any marine reciprocating steam engine, to respect the men and materials involved in maintaining its operation.

It has already been stated that lubrication is an essential to such operation. For this reason the lubricating oils and greases required must be of distinctive quality, otherwise the men of the engine room will be hard-put not only to keep things running cool, but at times in making repairs. To carry out the latter at sea is nerve-racking and often hazardous, for ship motion at standby is entirely controlled by the action of the sea.

Lubrication of the marine reciprocating steam engine has also become of greater importance during the past generation due to the increased pressures and temperatures which

have been introduced. These have involved multiple expansions of steam, which have become so advantageous in using the higher and higher degrees of superheat which modern boiler design have made practicable; so the quadruple expansion engine came into being with its highly perfected valve mechanisms to enable most complete transition of heat into mechanical energy.

The main engine is obviously the heart of any marine installation. The earlier types were built horizontally, at first noncondensing and designed for paddle wheel operation. As steam boilers were improved, however, with consequent increases in steam pressure, curious and intricate variations in engine construction came about, including such arrangements as the oscillating engine, the beam engine, side lever construction, inclined engines and the trunk type. All the above were relatively slow speed, so when the screw propeller was introduced, gearing was adopted to speed up the shaft and gain the required propeller efficiency. From this stage the transition to the modern vertical, multiple expansion condensing engine was rapid. It was necessary, however, for the latter naturally to pass through a series of stages of mechanical development, to conform with the increases in power which were made available by increased steam pressures. To obtain the full benefit of these latter, multiple expansion engines were designed equipped with two or more cylinders of increasing size in order to reduce the effects of cylinder condensation by reduction of the temperature ranges involved.



Courtesy of The American Ship Building Co.

Fig. 1—A four crank triple expansion steam engine. Note lubricators and piping on topside.

All this led to a variety of ways of combining these expansions, the location of the cylinders, the crank angles and the sequence in which the cranks operate. So we had first the high pressure cylinder located vertically above the low, in a sort of steeple arrangement. Then the compound engine was developed to include two or three cylinders and one or two cranks. All these ideas today, however, have given way to the modern in-line type engine built fore and aft. At times the latter is also built to include a low pressure steam turbine which takes the exhaust from the low pressure cylinder, and functions on the main shaft through a suitable oil hydraulic coupling connection. In ocean-going service this idea has been claimed to increase the effective power output by some twenty per cent.

LUBRICATING SYSTEMS

Lubrication systems on reciprocating steam engines may be divided into two classes:

(1) As designed for the internal contact surfaces of pistons, cylinders, valves, and stuffing boxes, and

(2) As applying to external bearings which are not enclosed within the parts of the engine exposed to steam.

In marine reciprocating engines where the problem is largely one of external lubrication, there is oftentimes opportunity for conserving oil through careful study of oiling methods. From the engine to the propeller, external lubrication for the prevention of friction losses is necessary at the crossheads, guides, valve gears, eccentrics, main bearings, crank pins,

thrust bearings, and propeller shaft bearings.

In connection with hand oiling as well as with any automatic lubrication system, the question of economy in the use of lubricants resolves itself into a personal equation to a large extent. The average oiler may be prone to place too much reliance upon self-feeding devices, and as a result, become lax in his attention to the journals. If he is compelled to oil by hand at all speeds, he will be much more proficient at full speed when the machinery requires the greatest care. Where one oiler, by vigilance and good judgment, can keep an engine running cool with a certain allowance of oil, another may use twice as much with no better results.

INTERNAL LUBRICATION

Any oil for internal or steam cylinder lubrication must:

(1) Blend thoroughly with the steam.

(2) Adhere to wet surfaces under conditions of friction, high temperature, pressure and steam velocity.

(3) Lubricate steel and iron surfaces, which surfaces must necessarily fit tightly in order to prevent steam leakage.

Lubrication requirements of the interior of the steam engines of the past, differed but little from those of the present day, excepting that in those days, speeds were less, pressures lower and the steam wetter.

Before the advent of mineral oils, marine engines were lubricated with sperm or whale oil, by a vegetable oil such as rape seed or olive oil, or in some cases with lard oil. One excellent reason for the abolition of animal oils, especially lard oil, was the bad stench which it created when it drained into the engine room bilges. Animal oils were also liable to clog up the distributing pipes unless they were cleaned out frequently. Irrespective of these fundamental defects possessed by animal and vegetable lubricants, the price today would make them commercially impossible as lubricants for this very extensive class of service.

In the early stages of the petroleum industry cylinder oils were extensively composed of tallow, containing sometimes as high as 50 per cent. In those days oils were fed wastefully through the old-fashioned tallow cup. Later the introduction of the hydrostatic sight-feed lubricator greatly assisted in the use of our modern free-flowing cylinder oils.

In steam cylinder lubrication, the lubricant must blend with the steam and, thus blended, adhere to the wet surfaces. If this does not occur, drops of lubricating oil may pass through the cylinder and out with the exhaust, probably without coming in complete contact with the surfaces to be lubricated. There is but little chance of oil adhering in drop form under the prevailing steam pressure and velocity. Cylinder oils must, therefore, be thoroughly vaporized or atomized by the steam.

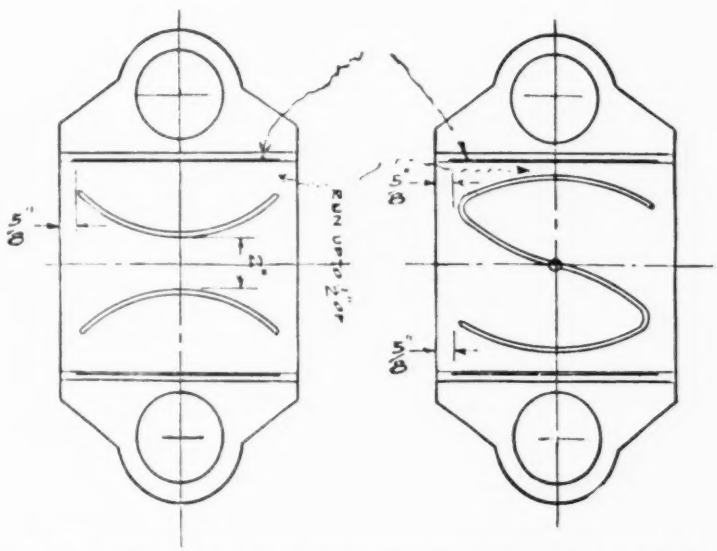


Fig. 2—Dimension details of a marine type crosshead bearing showing manner of grooving and chamfering of bearing edges. In this bearing grooves are approximately 1/4" wide by 3/16" deep. Top half is shown at right, with the bottom bearing at left. In preparing such bearings all burrs must be removed and grooves eased off at the ends.

Methods of Applying Internal Lubricants

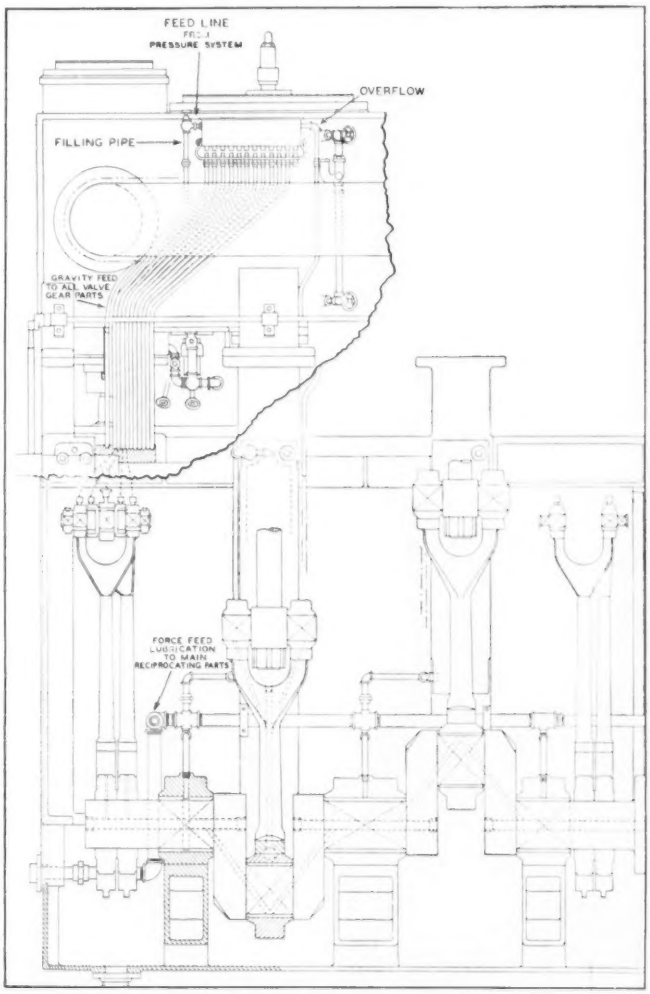
Internal or cylinder lubrication of reciprocating engines can be accomplished by a variety of methods, viz.: hand oiling, sight feed cups, hydrostatic lubrication and mechanical force feed oilers.

Hand pumps are also frequently installed for use when starting an engine or when there is a tendency for internal parts to groan. The hand pump must always be used with careful judgment as with this method more oil than is required may be pumped into the engine. The usual result is that the excess finds its way into the condenser with the exhaust steam and then back to the hot well and boilers.

The deficiencies of the oil cup as a method of cylinder lubrication are obvious. The cup is filled, the cover replaced, the cock at the base

opened and the oil permitted to flow into the cylinder or steam chest. This system lacks regularity, results in a waste of lubricant and demands frequent attention.

Hand swabbing, with cylinder oil, is effective on rods and packing, but this method is hardly satisfactory for cylinder and valve lubrication. Swabbing of rods must be done regularly; it can only be satisfactory when an oil of uniform quality and high refinement is used. Such an oil must have great spreading ability, the properties necessary for maintaining a lubricating and sealing oil film under high pressure and temperature and the ability to resist the washing effect of cylinder condensation; it must also furnish maximum lubrication with a small supply, it must not carbonize to excess, and it should be able to separate quickly from condensed steam in order to avoid boiler troubles. In contrast, where an oil of proper quality is introduced into the steam line by means of a mechanical force feed lubricator much less oil is required to accomplish the desired results and proper lubrication of all parts is more nearly assured without danger of subsequently introducing any oil into the boilers.



Courtesy of General Machinery Corp., Hooven, Owens, Rentschler Div.

Fig. 3—Details of a modern vertical reciprocating steam engine. Note provision for pressure lubrication on main reciprocating parts, with sight feed gravity lubrication to all valve gear parts.

When using a hydrostatic lubricator, the latter is connected to the main steam line, depending for its action on the replacement of oil with condensate from the steam line. This type of lubricator must be started and stopped by hand. It is not absolutely regular or uniform in its delivery of oil, as changes in temperature, leakage or an obstruction in the delivery passage alter the rate of feed. So it must be kept under observation to insure good results.

Force feed lubrication in turn is accomplished by the use of a mechanical lubricator, consisting of an oil reservoir and a small pump for each oil feed, operated by a lever and a ratchet motion which is attached to some moving part of the engine. There is a sight feed glass by which the rate of feed may be observed. There is also some means by which the stroke of each plunger may be regulated to increase or decrease the feed. When a mechanical lubricator is properly designed and working efficiently, it affords automatic and absolutely regular delivery of oil. The stroke may be adjusted to deliver the desired quantity of oil and by trial a very high degree of economy can be attained. Temperature changes do not influence the feed of a good mechanical lubricator.

ENGINE DESIGN

Horizontal Engines

Although horizontal engines are rapidly disappearing, they are still employed to some extent on harbor and river craft. Cylinder lubrication in such engines involves a somewhat more intensive problem than in vertical engines. In a horizontal cylinder, except where

tail rods are used, the weight of the piston, rings and part of the weight of the piston rod must be borne by the lower portion of the cylinder. On account of this weight the piston will frequently tend to wear the bottom of the cylinder out of round, and unless sufficient lubrication is provided, the clearance between the piston and cylinder may become so great as to cause serious leakage of the steam past the piston. This increases the pressure to which the oil film is subjected and may weaken or entirely destroy it.

If the rings become worn and sharp on the edges they will scrape the oil film off the surface of the cylinder walls, to further increase the friction and wear. Because of these conditions the cylinder oil must be able to provide a heavy lubricating film and must be used in sufficient quantities to maintain same. Even with the most efficient oil a certain amount of wear will take place and rings will have to be renewed occasionally.

Tail-Rod Supports an Advantage

Horizontal engines having heavy pistons and rods are, therefore, usually provided with tail-rod supports, which, together with the crosshead, carry the weight of the former. In such engines the only pressure on the cylinder walls is that developed by the tension of the piston rings, so a thinner film of oil and a lesser quantity of lubricant are required.

Vertical Engines

Vertical cylinders, on the other hand, are comparatively simple to lubricate as the weight of the piston, piston rod, crosshead and connecting rod are carried by the crank pin. The only pressures on the cylinder walls are those due to tension of the piston rings and possibly to some slight pressure from any side motion which the piston may exert.

Piston rings, regardless of their design, should be accurately set, and just tight enough to prevent any abnormal steam leakage. A film of oil thick enough to prevent excessive friction between these rings and the cylinder walls, and enough oil to maintain this film, are all that is required to provide proper lubrication.

In the vertical marine engine where condensed steam is used as make-up boiler feed, wherever adequate oil separation may be impracticable, it will frequently be advisable to run without any cylinder lubrication, on the assumption that the amount of water present in the steam will afford the necessary lubrication.

The space rings and piston usually have water grooves to hold a small amount of condensed steam which serves to decrease steam leakage, making it possible to use looser fitting rings and consequently decreasing the friction. After a short time, these cylinder walls become highly polished and glazed, so that the actual friction is decreased.

Piston and Valve Rods

Piston rods, tail-rods, and valve stems to operate effectively require quite as efficient

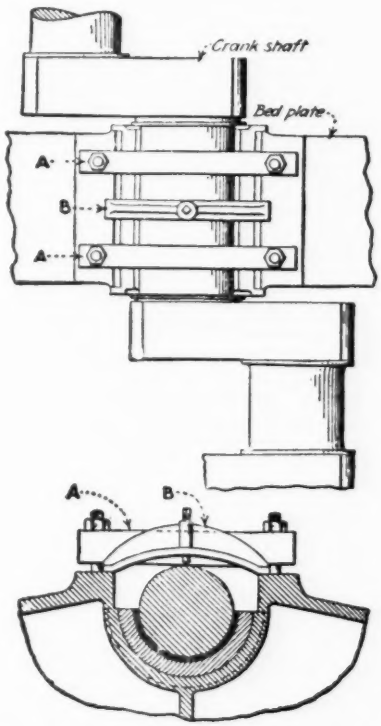
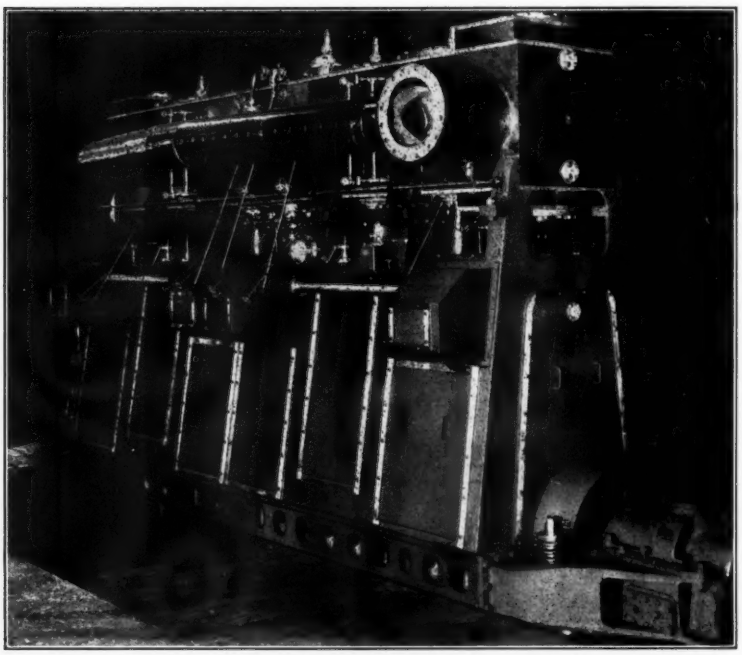


Fig. 4—One way of testing shaft alignment is to replace bearing by straps "A" as shown, laying a piece of wood or copper between strap and shaft and tightening the nuts, thus pressing the shaft tight on the lower bearing shell. A testing tool "B" is arranged in place and a feeler gauge used to measure the distance between shaft and set screw of the testing tool. After a shaft is once properly aligned, its exact alignment can be conveniently checked in this fashion.

lubrication as valve seats and cylinder walls. While it is usually considered the duty of a cylinder oil to lubricate these latter, it must not be forgotten that detrimental results may occur if they are neglected. It must be remembered that both valve and piston rods are very accurately machined and adjusted; therefore, any overheating due to lack of lubrication might cause a change in alignment, with ultimate damage to the internal mechanism of the engine. The practice of automatically oiling piston rods and valve stems has not been regarded with favor by many engineers, inasmuch as the lighter oils, such as are used in overhead reservoirs for the other running parts, are almost worthless on hot rods. An

occasional swabbing with thick cylinder oil prepared for such service will, in most cases, suffice to prevent undue heating.



Courtesy of General Machinery Corp., Hooven, Owens, Rentschler Div.

Fig. 5—Showing manner in which the modern marine steam engine can be enclosed to enable force feed lubrication of running parts.

Influence of Valve Design

In the lubrication of reciprocating engines steam valve design is a decided factor. The two types of valves usually met with are the single- or double-ported slide valves, and inside or outside type piston valves.

The Slide or "D" Valve

The common slide valve is often difficult to lubricate due to inequalities of pressure and the consequent "wiping" action which it exerts upon the lubricated valve seat. Therefore, where a lubricant is applied, the oil film must be continuously renewed, otherwise ineffectual lubrication may result, with cut or worn valves and seats. The above can normally be detected by jerky motion of the valve stem which is caused by momentary sticking of the valve to the seat.

Piston Valves

With the piston valve, on the other hand, the steam pressure is balanced, and as a result there is less tendency for the oil to be squeezed or wiped from the valve seat. As a result, piston valve engines can operate under considerably higher pressures than certain other types of engines.

Where superheated steam is employed, or even with high pressure saturated steam, inside piston valves will enable confinement of the high temperatures between the upper and lower valve faces, thus relieving the valve stem packing.

Equilibrium Piston

The work of moving a heavy steam valve up and down puts a large amount of work on the eccentric and is the reason why many eccentrics run hot. To offset this an assistant cylinder can be located on the top of the chest. This cylinder, in which is fitted an equilibrium piston, is open to the bottom to the valve chest, and hence the full pressure of the steam in the chest acts constantly on the lower side of the piston. This may be so proportioned as to carry practically all the direct weight of the valve, which thus floats on the steam, requiring comparatively little effort on the part of the eccentric to move it up and down.

Condition of Wearing Surfaces

In general, the real test of a cylinder oil should be the condition of the wearing surfaces upon which it is used. A hasty decision as to the suitability of such an oil should be guarded against, as time is necessary for the

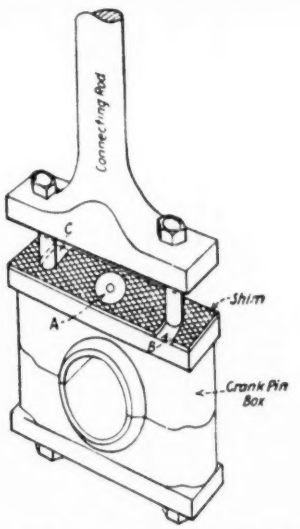


Fig. 6—Illustrating a method of cutting shims or liners whereby they can conveniently be inserted or removed between the stub end of a connecting rod and crank box in order to obtain the proper clearance.

lubricating film to form and function properly. Any test should, therefore, cover a reasonable period of time. When the vessel is in port and opportunity is available to remove the cylinder heads and valve chest covers, the interiors should be examined.

If, upon immediate inspection, the wearing surfaces show a film of lubricant sufficient to penetrate and leave a brownish stain on three or four thicknesses of cigarette paper they may safely be regarded as being sufficiently lubricated. If below this film they appear highly polished and of a color varying from bright iron-white to steel-blue they have been properly lubricated.

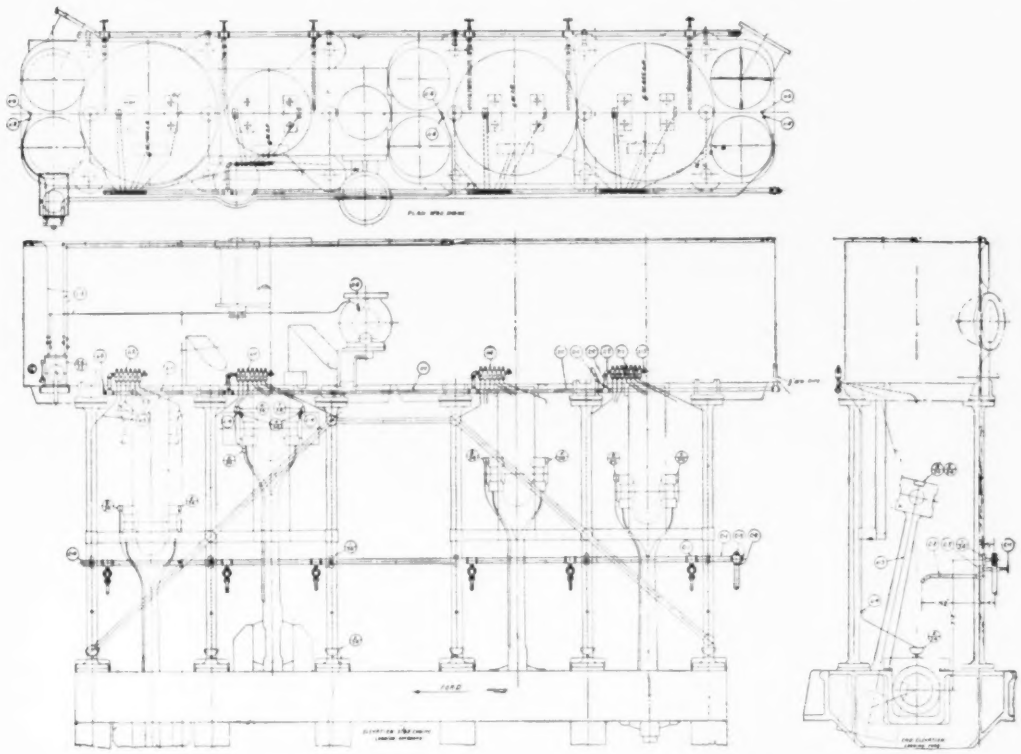
Where the surfaces are rough, dry, dull in appearance or rusty, lubrication has either been insufficient or the wrong grade of oil has been used. In addition, if the stain on the cigarette papers appear streaked, blackish or mottled, either the oil has been subject to carbonization or abnormal wear has taken place.

Lack of lubrication will also sometimes be evinced when the engine is running, by sticky valves or groaning sounds from the cylinder.

LUBRICATING REQUIREMENTS WITH SUPERHEATED STEAM

The use of superheated steam has decidedly economical advantages in marine service. Superheated steam does not condense until its temperature has been reduced to that of saturated steam at the same pressure. Also, it has a greater volume per unit of weight than saturated steam at the same pressure, the volume increasing with the temperature.

It has been explained how a vertical engine cylinder operating with saturated steam will eventually acquire what is known as a "water polish." This water polish acts as a protecting film and has a very low coefficient of friction. Where superheated steam is used, however, moisture is not always present. Absolute dryness only prevails where very high superheat is employed; even then the degree of superheat at the end of the expansion stroke or throughout the entire exhaust stroke is questionable. It is believed that in the neighborhood of 200 degrees Fahr., initial superheat at the throttle is required for any superheat to remain in the steam at exhaust when operating at about one-quarter cut-off. This means that practically all engines using superheat are

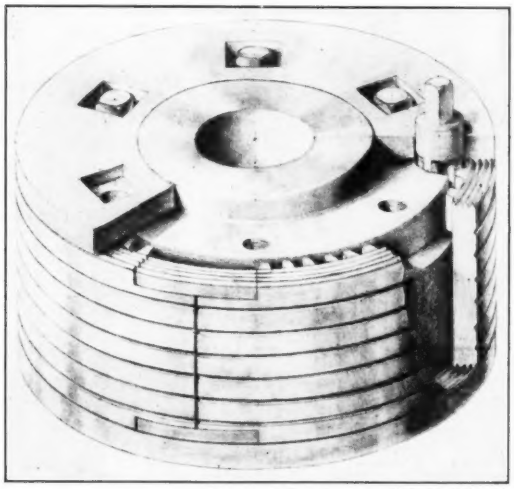


Courtesy of Bethlehem Shipbuilding Corp., Ltd.

Fig. 7—Arrangement of water and oil service piping for a Bethlehem marine reciprocating four cylinder, triple expansion steam engine.

operated on saturated steam for a portion of their expansion stroke and through the entire exhaust stroke.

Consequently, instead of a purely superheated steam condition, there is a dual problem presented in the selection of the most suitable



Courtesy of The American Ship Building Co.

Fig. 8—Details of the adjustable Bodenlose piston.

steam cylinder oil, viz., initial superheat with subsequent saturation or moisture conditions. The one oil must, however, be capable of meeting both types of service.

If there is not more than about 30 to 50 degrees of superheat, internal lubrication is sometimes effected by injecting a small amount of fresh water with the steam. This water serves the same purpose as the moisture in saturated steam. For superheat of a higher degree, however, it is necessary to use an especially prepared lubricant for the cylinders. Such an oil must not break down at temperatures as high as 700 degrees Fahr. In order to obtain efficient internal lubrication, the oil must possess the necessary qualifications to maintain a lubricating film under the influence of high temperature and steam condensation, and it must be properly atomized and distributed by the steam to the valve seats and cylinder walls.

It is generally impractical to use superheated steam in the auxiliaries due to the difficulty in effecting proper internal lubrication in the cylinders. The steam line supplying all auxiliaries is, therefore, usually planned to take saturated steam from the boiler before it enters the superheater.

Proper Grade of Lubricant Important

If condensation was not prevalent in a steam cylinder there would be no necessity for requiring a lubricant which would emulsify, and a straight mineral oil would be perfectly satisfactory. In multiple-expansion engines, however, especially where a low degree of superheat is used in the high-pressure cylinder, the exhaust from the intermediate cylinders will be relatively wet and the proper oil film will not be maintained.

For an oil to be suited to superheated steam conditions it should have a viscosity of about 165-195 seconds Saybolt Universal at 210 degrees Fahr., and contain a small percentage of animal compound. The latter will enable such an oil to emulsify slightly and thereby lubricate the cylinders very efficiently during that period when they are filled with saturated steam. As the compounding is slight no ill effects should result from the exposure of the oil to superheat conditions.

An approved type of lubricator should be used for applying steam cylinder oils where highly superheated steam is employed. The mechanical lubricator which works off the main engine is generally most economical and dependable. Where a hydrostatic type of lubricator is used, the cylinder oil should be thoroughly mixed with saturated steam previous to its admission to the main steam pipe, to prevent carbonization. Such steam can be taken from a convenient location on the saturated side of the superheater provided a difference in head of about two feet is available to mix the steam and oil. The mixture of steam and oil is then carried in globular form into the main steam pipe and thence to the high pressure cylinder.

Effect of Over-Lubrication

The excessive oil feeds which many engineers have considered necessary for superheated steam cylinders, are due to the use of a straight mineral cylinder oil and misunderstanding of the values of high viscosity, and high flash and fire. Any oil of this nature, while suitable for the lubrication of the cylinder, so long as the steam remains dry or superheated, is not adaptable for lubrication during that portion of the stroke when the steam is saturated, as the moisture washes the oil off the cylinder walls and the cylinder becomes dry. This results in wear, increased friction and noise. Consequently, the engineer will be prone to increase the amount fed, so that satisfactory lubrication may be secured, but in doing so, such a large amount of oil is fed to the cylinders that it is not carried away, and accumulations of carbon deposits will result.

In the lubrication of superheated steam cylinders, most of the troubles encountered have been caused by this carbonization of the oil, and deposits on the valves at the end of the valve travel and at the end of the counter-

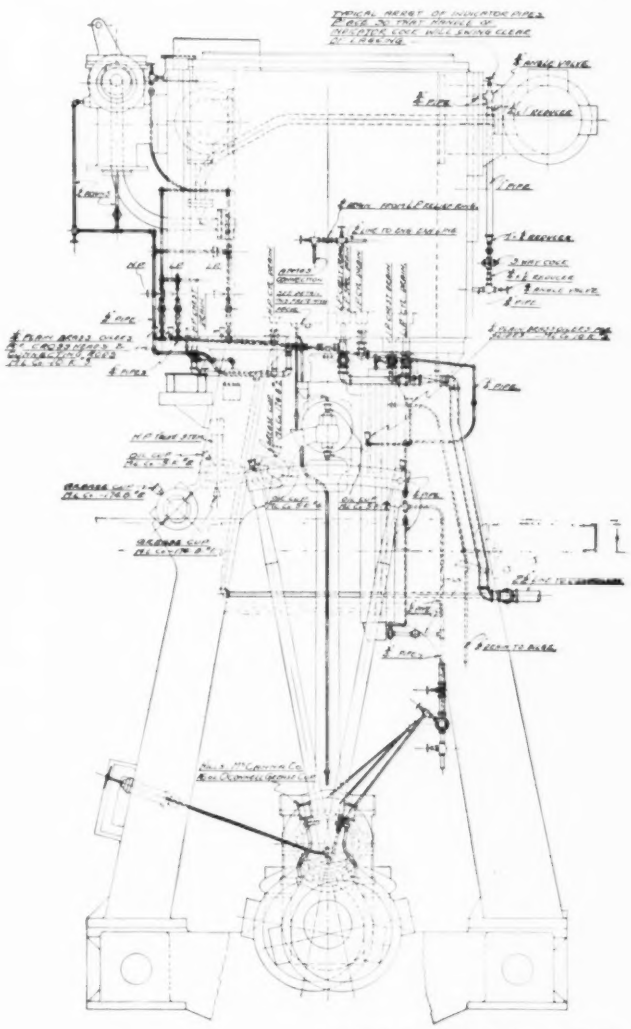
bore in the cylinders. Carbonization is caused by the oil remaining in contact with the hot surfaces and the superheated steam long enough for its lighter constituents to be vaporized and the oil partially decomposed.

CLASSIFICATION OF BEARINGS

Bearings may be classed generally under two divisions, journal bearings and thrust bearings. Journal bearings are cylindrical and the load is carried at right angles to the axis. When the load is carried or applied in a line parallel to the axis, the bearing is called a thrust bearing. A modification of the plain sleeve type of bearing in turn involves those parts designed for sliding motion. The crosshead guides of the reciprocating engine are typical of this being known as sliding contact bearings.

From a marine lubrication standpoint, it is necessary to differentiate further as there are a variety of conditions presented under each of the main classes. These include:

(1) Dead-running journals with uniform load always applied in one direction and a constant journal velocity.
(2) Bearings where the load is constantly shifting from one side of the bearing to the other, and where the load is not always uniform, such as on the crankpins and main bearings.
(3) Bearings where the motion is reversible.
(4) Bearings subjected to heat other than that generated by bearing friction, such as the heat developed by hot water or steam leakage.



Courtesy of Great Lakes Engineering Works.

Fig. 9—End view of a modern vertical engine showing details of piping for lubrication. Note extent to which grease lubrication is provided for.

Principles of Bearing Lubrication

The application of the lubricant to the bearings of reciprocating engines is governed by well established principles, viz.:

(1) It should, wherever possible, be led into the bearing at a point which is under the lowest pressure.
(2) The continuity of the oil film, where it is under the greatest pressure, should not be interrupted by oil channels or grooves.
(3) The lubricant should be prevented, as far as possible, from escaping at those points which are under the greatest pressure.

According to these principles the oil for the main bearings should be introduced near the division between the upper and lower brasses, and oil grooves in the metal of the bearing at the top and bottom should be omitted. Similarly, on the crank pin and other cylindrical journals, the oil should be admitted at those points where there is the least pressure, and at the points where the pressure is greatest the bearing surfaces should be smooth and not interrupted by grooves, scores, or oil channels of

any kind whatever. Where such practice is not adhered to, the grooves will break the oil film and conduct the oil away from the pressure area, frequently rendering proper lubrication impossible.

The division between the bearing halves of

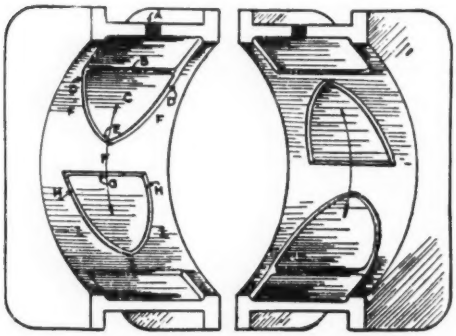


Fig. 10—Crank-pin boxes of a connecting rod showing oil grooves. Oil enters at "A"; is accumulated in the primary groove "B"; by rotation of the pin from there it is spread in both directions within the clearance space to cover surface "C". "D-D" are secondary grooves which carry oil back to the center of the bearing at "E" and at the same time maintain a film of oil over surfaces "F,F,F." From here oil works into primary groove "G" and thence to secondary grooves "H, H" where the course of development of the film is repeated as above.

cylindrical bearings is usually located at the sides. At this point the pressures are at a minimum. The bearing metal surface should be scraped or eased away near these joints, and a chamfer should be cut on the edge. In order to prevent the escape of oil, grooves should not be carried closer than about one-half an inch from the bearing end. It is also good practice to fit the shims or liners closely to the journal near the ends of the bearing, cutting away the middle portion to agree with the outline of the chamfers.

LUBRICATING PRACTICE

External Lubrication

External lubrication to reduce friction and wear to a minimum and to keep bearing temperatures within reasonable limits, may be carried out by hand, by oil cups, by gravity, wick feed, or forced-feed delivery of the oil, or a combination of these systems.

Hand Oiling

Hand oiling is quite extensively preferred on engine bearings which are subject to limited motion and small bearing loads. It is therefore used on valve and governor mechanisms, for slow speed rocker arms, and link motions. Hand oiling also supplements the regular gravity oiling system when the oiler makes his periodic half hour rounds. It is also a practice on some ships to give the oil cups on the top and bottom ends of connecting rods, links, eccentric gear, etc., a shot of fresh water when hand oiling, on alternate half hour rounds. This produces an emulsion with the oil film in the clearances, to not only improve the strength of the lubricating film but also to reduce the consumption of lubricating oil.

Gravity Wick Feed

Gravity wick feed systems, which involve the siphoning effect of strands of worsted yarn, can be classed as mechanical lubrication. The distributing centers are light cast brass boxes or manifolds, from which the oil is taken by brass piping as directly as possible to the various bearings, each having its own independent pipe and set of connections.

Each cylinder is provided with its own manifold which is located near the topside within reach of the grating at a point higher than any bearing to be reached by the oil. Each box is fitted with a cover, and has a capacity sufficient to last several hours without refilling. These oil boxes are provided with sight feed cups and protected glass tubes, from which pipes lead to wipers on the moving parts, or to tubes in the bearings and guides. Union joints are fitted where necessary, so that the oil pipes may be quickly taken down and cleaned.

The ends of the pipes in the oil box should extend above the normal oil level in the manifold, to within about two inches of the top. The feed is regulated by worsted yarn wicks which give a regular and reliable supply of oil acting at the same time as automatic filters and strainers. Each is fitted with a lead sinker on one end and a twisted wire on the other. The sinker ends are submerged in the oil in the manifold, the wires being inserted in the feed pipes. Oil travels up the wicks by capillary action and siphons over, to subsequently drip into the pipes and be led to the various parts.

As with other methods of lubrication, the rate of oil feed should be maintained practically constant and only in sufficient volume to lubricate the bearings adequately. This is, however, difficult to accomplish. When the oil manifold box is full, the oil flows freely, decreasing, however, as the level falls. If at the low levels the bearings are receiving sufficient oil, then when the rate of flow increases with higher levels the conclusion must follow that oil is being wasted. In the great majority of cases wick feeds supply more oil than is necessary assuming high grade lubricants are employed.

The possibility of changing the number of strands in a wick and of determining the proper length wick to give correct flow and avoid fluctuation is of great importance. Tests

have indicated that with the lower end of the wick set at a distance of about two inches below the lowest oil level an increase in the uniformity of flow at all levels will prevail. Greater wick lengths than this do not alter the effect appreciably, but if the wick is much shorter there will be an excessive variation of oil flow between fillings.

As dirt filtered from the oil causes a wick to become gummy and lose its filtering effect, wicks should be stripped once every watch when the engine is in operation to guard against cessation of lubrication. The entire wick should never be too heavy, and judgment must be used in deciding on the number of strands suitable. Were too many strands used, capillary action would be retarded and if the wicks were not regularly stripped, lubrication might even be discontinued. All wicks should, of course, be removed from the tubes when the machinery is secured to prevent waste of oil; periodic rinsing in kerosene is also advisable.

Force Feed Lubrication

Force feed lubrication involving straight mineral oils, is becoming very advantageous on high speed engines. With such installations all working parts of the main engine except the valve gear, but including the thrust bearings, are served in this manner. Each engine is usually fitted with its own individual pumping system; in fact, it is common practice under ordinary circumstance to run the lubricating system cross-connected using two pumps even though one pump will maintain the pressure. With this arrangement the failure of one pump will not cause a complete failure of the lubricating system.

In a force-feed lubricating system oil-drain tanks are provided to which the oil is led after having passed through the various bearings and other points of the system. Oil coolers keep the oil at the desired temperature, while oil-settling tanks allow the water and other impurities to settle when there is an accumulation thereof in the oil. In modern installations all purification of oil is accomplished with centrifugal purifiers. The entire engine is enclosed in a sheet steel casing to prevent splashing and waste of oil which also makes possible the return of the used lubricant to the filter and service tank.

Object of Compounding

Marine engine oils adapted to hand oiling or wick-feed systems are today generally compounded with blown rapeseed oil in varying percentages up to 20 per cent. The object in compounding mineral oils with blown rapeseed oils is to give them the necessary emulsifying qualities. After an oil has become emulsified with water its viscosity is raised and its adhesive and cohesive qualities are greatly increased. In this condition the oil film is able to resist the washing effect of water, which is always present around a marine engine.

APPLICATION OF LUBRICANTS

Main Bearings

Main bearings are oiled by one or more wick cups or pressure feed leads which deliver the oil to the points desired. On some large reciprocating engines these bearings will be provided with four oil inlets, leading in pairs to the chamfers at the bearing sides. In addition, a grease cup may also be provided as well as a hole through which the shaft may be felt by hand to ascertain any tendency toward heating.

In the majority of installations, however, two oil inlets are deemed sufficient. These should preferably introduce the oil where the bearing pressure is lowest and be so located as to divide the length of the bearing into three approximately equal parts. When oil inlets must be located within the pressure area, the cutting of circumferential oil grooves or channels through the oil inlets will facilitate the passage of the lubricating oil from the inlets to the chamfers at the sides of the bearing. These chamfers, acting as channels, in turn serve to bring about longitudinal distribution of the oil. The difficulty in supplying proper lubrication to a cylindrical bearing arises from the fact that oil will not flow at right angles to the axis of the journal, but has a tendency to flow at various angles from such lines, and always toward the ends.

Water Service

Water service is provided to each of the main bearings as a safeguard in case of overheating. Due to water jacketing of these latter, leakage must be taken into consideration; this is perhaps the primary reason for the use of a compounded oil on such bearings where wick feed delivery prevails. In other words emulsified lubrication is desired and planned for. Effective lubrication with such a product is denoted when the cream-like lather can be picked up by the fingers; if it feels smooth and of a soapy nature, journals and bearings are running satisfactorily, but when the lather or emulsion presents a dark brown or blackish appearance this can be taken as an indication that the journal or bearing is running overheated; this should be advance notice to the engineer of impending trouble.

Crank Pins

In the lubrication of crank pins by the conventional wick-oiling manifold method, oil is

distributed by means of a pipe or pipes securely fastened to each connecting rod, and cups carried on each respective crosshead. These pipes run down the side of the rod, or, if the rod is hollow, within same, to connect with the oil duct leading through to the pin.

Crosshead Guides

The crosshead guides are provided with oil through pipes connected with holes at about the middle of each forward and backing guide. Well designed oil grooves must be cut in the surface of the guides as no natural continuous oil wedge formation can be developed on these flat surfaces as in the case of cylindrical bearings. By rounding or chamfering the edges of the grooves, however, individual wedge action at each point can be developed. Grooving of crosshead guides will, of course, vary, most usual practice, however, is to cut the grooves straight across the path of motion and space them approximately twelve to fourteen inches apart. It is important that such grooves do not extend to the sides of the guide surface in order to prevent escape and wastage of oil.

Guides are usually designed for internal cooling by water connections for dissipating the heat generated. It is also customary to attach combs to each crosshead, designed to dip into oil cups mounted on the lower ends of the guides. Thus, when each crank is on bottom center its respective guide comb will pick up a quantity of oil and water mixture from the cup and distribute same over the guide surface during the upward stroke.

Here again experienced marine engineers can judge the condition of guides by the appearance of the lubricant. The surfaces will present a smooth cream-colored appearance when the combs are evenly distributing the emulsified oil, and it is not even necessary to feel them to determine their operating temperature. When dark spots begin to appear, trouble is threatening and attention is required.

Eccentrics

The eccentric straps are fed from long narrow oil cups, receiving their oil through drip pipes from the manifold or lubricator reservoir. The length of the cup is such that some part of it is always under the drip in any position of the eccentric, which assures its always receiving an ample supply. The various other parts of the gear are similarly provided for lubrication either from a drip or a wiper, whichever may be most convenient. Eccentrics, as a rule, require a considerable amount of oil, but if they are so arranged that the lower part of the straps dip into fresh water in the drip pans, they will often run cool on a greatly reduced amount of oil, as compared to those which are simply oiled. These eccentric pans or water troughs should be cleaned at frequent intervals.

Reversing Mechanism

The Stephenson double bar link motion is the usual type of mechanism employed for marine reversing reciprocating engines. It is provided with linking-up screws for the purpose of changing the point of cut-off of the steam. The link block, the link pins on the bridle rods, and the bearings of the rocker or reversing shaft are usually provided with oil cups of ample size filled with felt or horse hair, and fitted with cross wires for hand oiling on account of the intermittent operation. As there is little motion at these points the tendency of the oiler may be to overlook them, the link block, however, should be regularly inspected and lubricated to reduce the wear on the composition gibs between which the link moves. Link blocks and saddle pins frequently run at high temperatures due to steam and hot water leakage past the valve stem packing.

The reverse shaft bearings in turn are usually fitted with compression grease cups. The reversing engine for operating the reverse gear is usually bolted to one of the main engine columns and has floating links and levers controlled from the starting platform. The cylinders of the reversing engine are lubricated by swabbing the piston rod during operation.

Thrust Bearings

Lubrication of these elements is important for any overheating of the rings, collars or slippers due to lack of oil may soon cause scoring of the bearing metal or contact surfaces. Wick feed, force feed or bath lubrication are generally used. Wick feed, supplemented by bath lubrication is employed on horse-shoe or plain thrust bearings. Here a compounded oil as used on the main engine is best adapted, running the thrust elements on an emulsion of water and oil. On thrust bearings of the slipper type, however, force feed lubrication, using a highly refined straight mineral oil, is generally preferred. Here elimination of emulsified matter aids materially in enabling the bearing to function at its best without abnormal temperature rise.

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